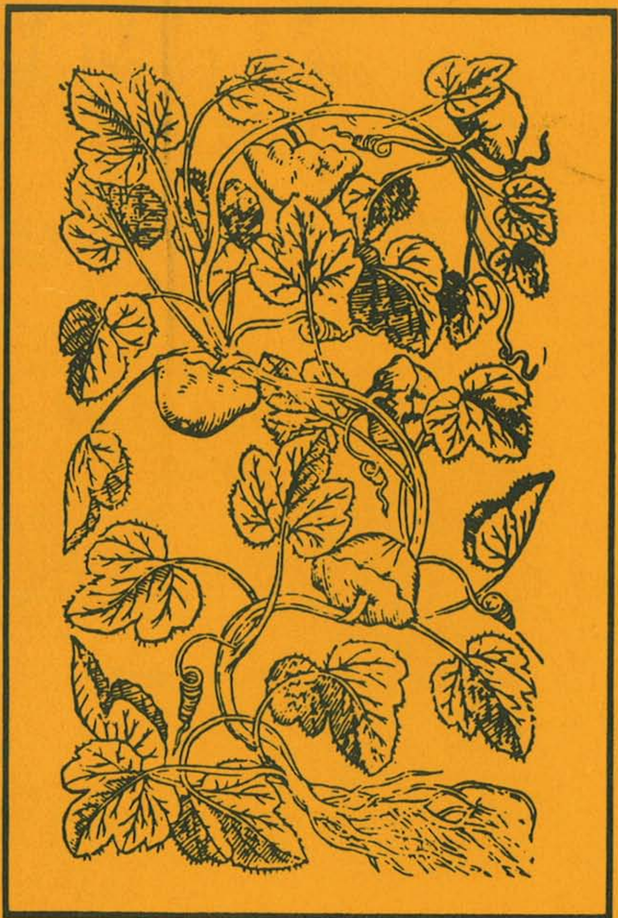
Program and Abstracts

CONFERENCE ON THE BIOLOGY AND CHEMISTRY OF THE CUCURBITACEAE



August 3-6, 1980

Cornell University, Ithaca, New York

Organizing Committee:

D. M. Bates, L. H. Bailey Hortorium, Cornell University
C. Jeffrey, Royal Botanical Gardens, Kew
R. W. Robinson, New York State Agricultural Experiment Station

PROGRAM

Conference on the Biology and Chemistry of the Cucurbitaceae

August 3-6, 1980

Sunday, August 3, 1980
Main Lobby, North Campus Union, Cornell University

Afternoon and evening — Registration

7-9 p.m. — Informal get-together, 2nd floor lounge, North Campus Union

Monday, August 4
Boyce Thompson Institute for Plant Research, Cornell University

8-9 a.m. — Registration

9-9:30 a.m. — **Welcome**
D. M. Bates, Director, Bailey Hortorium, Cornell University

Opening Remarks
R. W. Robinson, New York State Agricultural Experiment Station, Cornell University, Geneva, New York
C. Jeffrey, Royal Botanic Garden, Kew, England

9:30 a.m.-12 noon — **THE BROADER CANVAS**

Moderator: D. L. Mulcahy, University of Massachusetts

C. Jeffrey, Royal Botanic Garden, Kew, England. *Taxonomy and economic potential of the Cucurbitaceae.*

R. K. Arora, K. L. Mehra, and **E. R. Nayar.** National Bureau of Plant Genetic Resources, India. *Genetic resources of cultivated and related wild cucurbits in India.*

A. S. R. Dathan, University of Rajasthan, India. *Embryology of the Cucurbitaceae.*

D. Singh, University of Rajasthan, India. *Seedcoat anatomy.*

L. Fowden, Rothamsted Experimental Station, England. *Amino acids as chemotaxonomic indices.*

C. Y. Hopkins, Research Chemist, Ottawa, Canada. *Fatty acids of seed oils as a taxonomic character.*

D. L. Mulcahy, University of Massachusetts, USA. *Electrophoresis of proteins of single pollen grains.*

1:30-5 p.m. — **CUCURBITS IN CULTIVATION**

Moderator: H. M. Munger, Cornell University

H. L. Chakravarty, Calcutta, India. *Cucurbits of India and their role in the development of vegetable crops.*

G. W. Bohn and **A. N. Kishaba**, U. S. Department of Agriculture, Brawley and Riverside, California, USA. *The nature of resistance in* Cucumis melo *to* Aphis gossypii, *genetic controls, and their manipulation in breeding.*

R. L. Lower and **J. Nienhuis**, University of Wisconsin, USA. *Prospect for increasing yield of* Cucumis sativus *via* Cucumis hardwickii *germplasm.*

H. M. Munger, Cornell University, USA. *Breeding cucurbits for multiple disease resistance.*

R. Provvidenti, New York State Agricultural Experiment Station, USA. *Viral diseases and genetic sources of resistance in* Cucurbita.

S. D. Ugale, Indian Agricultural Research Institute, India. *Cytogenetic studies in* Coccinia indica *W and A.*

R. W. Robinson, New York State Agricultural Experiment Station, USA. *Genetics and breeding of* Cucurbita *and* Cucumis.

O. Shifriss, Rutgers University, USA. *The concept of timer genes in relation to fruit pigementation and quality in* Cucurbita.

6-7 p.m. **Cash bar**—Private dining room, third floor, North Campus Union

7 p.m. **Banquet**—Private dining room, third floor, North Campus Union

T. W. Whitaker, Geneticist Emeritus, U. S. Department of Agriculture, La Jolla, California, USA. *Exploring for Cucurbits in Old Mexico.*

Tuesday, August 5

Boyce Thompson Institute

8-10 a.m. **CUCURBITS IN THE ECOSYSTEM**

Moderator: W. P. Bemis, University of Arizona

R. L. Metcalf, University of Illinois, USA. *Coevolution of* Cucurbita *and* Diabroticites.

J. T. Puchalski and **R. W. Robinson**, Botanical Garden of the Polish Academy of Sciences, Poland, and the New York State Agricultural Experiment Station, USA. *Electrophoretic analysis of isozymes in Cucurbitaceae and its application for phylogenetic studies.*

W. P. Bemis, University of Arizona, USA. *Domestication studies of* C. foetidissima *and comments on the potential of* Cucurbita *digitata (group) and* Apodanthera undulata *as oil seed crops.*

J. Graham and **W. P. Bemis**, State University of New York and University of Arizona, USA. *Interspecific trisomics of* Cucurbita moschata.

S. P. Sen, M. Sen, B. S. Gupta, M. S. Choudhury, and **P. D. Ghosh**. *Nitrogen nutrtion of cucurbits.*

M. Condon, Guatopo, Venezuela. *Natural history and adaptive significance of sex switching in* Gurania *and* Psiguria.

10:30 a.m.-noon **THE BROADER CANVAS**

Moderator: A. M. Rhoades, University of Illinois

J. Guha and **S. P. Sen**, Surendranath College, India, and University of Kelyani, India. *Some growth regulators of the Cucurbitaceae.*

A. M. Rhodes, University of Illinois, USA. Cucurbita *species hybrids as a source of cucurbitacin.*

P. J. Hylands, University of London, England. *Recent developments in the triterpenes and steroids of the Cucurbitaceae.* and other terpenes.

J. A. Inamdar, Sardar Patel University, India. *Structure and ontogeny of stomata and trichomes: morphogenetic effects and their taxonomic significance.*

1 p.m. **FIELD TOUR**

Plant breeding plots, Varna, New York.
Breeding cucumbers, muskmelon, and squash.

Robson Seed Company, Hall, New York
F1 hybrid squash seed production.

Vegetable Research Farm, Geneva, New York.
Genetics and breeding of Cucumis *and* Cucurbita; *Mutants and species of the Cucurbitaceae.*

6 p.m **Barbecue**, Pavilion, New York State Agricultural Experiment Station, Geneva, New York.

Wednesday, August 6
Boyce Thompson Institute

8 a.m.-noon **CUCURBITS IN CULTIVATION**

Moderator: E. Galun, Weizmann Institute

B. Loy and **C. Broderick**, University of New Hampshire, USA. *Nutritional status of winter squash.*

D. J. Cantliffe, University of Florida, USA. *Fruit set and development of the cucumber.*

E. Galun, Weizmann Institute, Israel. *Genetic and physiological regulation of stamens and ovary differentiation in the cucumber floral bud—an overview.*

J. Rudich, Hebrew University of Jerusaleum, Israel. *Biochemical aspects of hormonal regulation of sex expression in cucurbits.*

A. D. Taylor, Robson Seed Company, Hall, New York, USA. *F1 hybrid cucurbit seed production.*

J. D. McCreight, U. S. Department of Agriculture, California, USA. *Phenotypic variation of male fertile and male sterile segregants of* male sterile-*1 and* male sterile-*2 in muskmelon (*Cucumis melo *L.).*

T. W. Whitaker, U. S. Department of Agriculture, California, USA. *The economic importance of the Cucurbitaceae and their use as experimental material.*

A. P. M. den Nijs, Institute for Horticultural Plant Breeding, Wageningen, The Netherlands. *Resistance breeding by interspecific hybridization in* Cucumis.

1-2:30 p.m. **THE BROADER CONCEPT**

Moderator: H. L. Chakravarty, Calcutta, India

S. V. S. Chauhan, R. B. S. College, India. *Mechanism of male sterility in some Cucurbitaceae.*

R. P. Roy and **B. Dutt**, University of Patna, India. *Evolution in the genus Luffa.*

R. P. Roy and **S. Saran**, University of Patna, India. *Dioecism in Cucurbitaceae.*

K. L. Mehra, National Bureau of Plant Genetic Resources, India. *Ethnobotany of the old world cucurbits.*

B. Sandelowsky, University of Tucsin, Namibia. *Archeological research with* Acanthosicyos.

3 p.m. **GENERAL DISCUSSION, SUMMARY, AND RESOLUTIONS**

Moderator: C. Jeffrey, Royal Botanic Gardens, Kew, England

Genetic Resources of Cultivated and Related Wild Cucurbits in India

R. K. Arora, K. L. Mehra and E. Roshini Nayar
National Bureau of Plant Genetic Resources
New Delhi-110012, India

In India cultivated and wild cucurbits are distributed all over the tropical and sub-tropical parts, extending to the Himalayas, with a preponderance in the sub-tropical belt. Out of the ca. 36 species and 18 genera of the cultivated world taxa of Cucurbitaceae, about 18 species and 11 genera are grown in India. In addition, 43 species of cucurbits occur here, of which 26 are species of *Trichosanthes*. Other well represented genera include *Cucumis*, *Luffa* and *Momordica*. The cultivated taxa of Indian origin are *Citrullus lanatus* var. *fistulosus*, *Coccinia cordifolia*, *Cucumis melo* (several varieties), *C. sativus*, *Luffa acutangula*, *L. aegyptiaca*, *Momordica charantia*, *M. cochinchinensis*, *M. dioica*, *Trichosanthes anguina* and *T. dioica*. The cultivated taxa of exotic (African and New World) origin are also grown, and species of *Lagenaria* and *Cucurbita* exhibit secondary centers of genetic diversity in India.

The nature and extent of variation in selected plant characters among the traditional cultivars of both indigenous and exotic cultivated species is discussed. The geographic regions possessing a higher concentration of genetic diversity of different cultivated species are summarized. Similarly, geographic regions having specific economic traits of cultivated species are indicated, as aids to help future plant collectors to collect desirable genotypes. The geographic distributions of the related wild species are also given and the centers of species concentration are outlined. Differential phyto-geographic studies revealed that, while the indigenous cultivated species exhibit rich genetic diversity along much wider present day geographic limits of their cultivation, the humid sub-tropical parts of eastern India and especially the north-eastern region possess a high concentration of wild species. The humid tropical region, including the western Chats, is yet another minor center of concentration of wild species. Present and future plans for collection and conservation of genetic resources of the Cucurbitaceae in India are summarized.

Domestication Studies of Cucurbita foetidissima and Comments on the Potential of Cucurbita digitata (group) and Apodanthera undulata as oil seed crops.

W. P. Bemis
Department of Plant Sciences
The University of Arizona
Tucson, Arizona 85721

The buffalo gourd, *Cucurbita foetidissima*, is a feral species which has evolved in the arid to semi-arid areas of western North America. It is a perennial vine and prolific producer of gourd-like fruit containing seed having 35-40 percent edible oil and 30-35 percent protein. It also produces an exceedingly large storage root containing 18-20 percent starch. Archaeologic artifacts indicate this species has been associated with prehistoric man for about 10,000 years.

The multi-discipline approach to rapid domestication of this species is described including plant collections, genetic variability, germ plasm evaluation, seed production for homogeneous populations, early testing and product evaluation.

The species of the *Cucurbita digitata* group are extreme perennial xerophytes. They are prolific producers of 5-carpelate gourd-like fruit containing up to 600 seeds per fruit. The seed oil contains from 15-20 percent conjugated fatty acids which makes it doubtful as an edible oil, but could be used as an industrial or combustionable oil.

Apodanthera undulata, a perennial species indigenous to southwestern United States and adjacent areas in Mexico, produces a dense prostrate vine with soft melon-like fruit, 7-10 cm in length and 4-5 cm in width. The fruit are essentially seedballs containing about l00 seed per fruit weighing approximately 14 g. per 100 seed. The seed contains about 33 percent protein and 35 percent crude fat. The crude fat contains about 5 percent conjugated dienes and 15-20 percent conjugated trienes (punicic acid). This characterizes the oil as an industrial (drying) oil or a combustionable oil.

The Nature of Resistance in Cucumis melo to Aphis Gossypii, Genetic Controls and Their Manipulation in Breeding

G. W. Bohn and A. N. Kishaba
United State Department of Agriculture
Science and Education Administration, Agricultural Research
Brawley and Riverside, California

American cultivars are susceptible to the melon aphid which causes young leaves to curl, young plants and plant parts including fruits to be stunted, mature leaves to become nonthrifty and eventually necrotic, and large fruits to be discolored by sooty mold. The flesh of fruits on severely damaged plants often has poor color, texture, and flavor and low soluble solids content.

Resistance to the melon aphid in muskmelon PI 371795 from India included antixenosis (nonpreference), tolerance, and antibiosis. We ignored antixenosis, used mass infestation of young seedlings to test for tolerance, and used survival and reproduction of caged insects to test for antibiosis in young-mature plants. Tolerant plants with high antibiosis from the two tests performed in sequence were used for breeding.

Tolerance included freedom from curling, controlled by the gene, *Ag*, and freedom from stunting, controlled by polygenes. Antibiosis appeared to be controlled by 3 or 4 genes. The gene *Ag* and at least some of the genes controlling freedom from stunting and antibiosis were dominant, so direct backcrosses were made to American cultivars.

The appearance of fruits on some plants in third and fourth backcrosses indicated that successive backcrosses made good progress from the resistant Indian cooking melon toward the American desert melon. The low frequencies of high quality melons among resistant inbreds from third, sixth, and even ninth backcrosses indicated the desirability of continuing to the twelfth backcross to commercial recurrent parents.

Fourth and fifth generation inbreds with high quality, with flat leaves and good vigor after mass infestation, and with good antibiosis to the aphid are now being increased for release.

Cucurbits of India with Reference to Crop Development

H. L. Chakravarty
Calcutta, India

Fifteen common Indian cucurbits grown for agricultural purposes have been discussed, particularly with reference to their cultivation and economic uses. A short botanical account and a short account of areas under cultivation have been noted. The cucurbit vegetables discussed come under nine genera, the species dealt with being *Trichosanthes anguina* Linn., *T. dioica* Roxb., *Lagenaria siceraria* (Molina) Standley, *Luffa cylindrica* (Linn.) Roem., *L. acutangula* (Linn.) Roxb., *Benincasa hispida* (Thumb.) Cogn., *Momordica charantia* Linn., *M. dioica* Roxb. ex Willd., *Cucumis melo* Linn., *C. sativus* Linn., *Citrullus lanatus* (Thumb.) Matsumara, *Cucurbita maxima* Duchesne, *C. moschata* (Duch. ex. *Lam.*) Duch. ex poir., *C. pepo* Linn., and *Sechium edule* (Jack) Sw. Of these 15 cucurbit vegetables, *Cucumis melo* (melons) and *Citrullus lanatus* (watermelons), strictly speaking, afford excellent dessert fruits of superb quality and may not be counted as simply vegetable. *Lagenaria siceraria* (bottle gourd), *Luffa acutangula* (angular sponge Luffa), *Trichosanthis dioica* (pointed gourd), *T. anguina* (snake gourd), *Benincase hispida* (white gourd), *Momordica charantia* (bitter gourd), *Cucurbita maxima*, *C. pepo*, *C. moschata* (pumpkin, vegetable marrow or squashes) and lastly *Sechium edule* (chocho) are extensively cultivated all over India and may be found in every village corner of this vast country, grown as kitchen garden vegetables, apart from their cultivation in the agricultural farms.

A short recommendation for their improvement has been stressed upon. Special attention has been laid to cultivate melons and watermelons on a scientific basis in the non-productive dry and desert areas of India where their settlement is possible, as is done in the Middle East and the U.S.A. Cucurbits as a vegetable being less exacting to cultivate, due to the advantage on their luxuriance of growth, and their food value have been dealt with in the paper.

Mechanism of Male-sterility in Some Cucurbitaceae

S. V. S. Chauhan
Department of Botany
R. B. S. College
Agra, India

A comparative morphological, histochemical and biochemical study in male-fertile, genic male-sterile as well as chemically induced male-sterile plants of *Cucumis melo*, *Cucumis sativus*, *Cucurbita maxima*, *Luffa cylindrica* and *Momordica charantia* was undertaken. Male sterility in genic as well as chemically induced male-sterile plants of above mentioned species was associated with tapetal abnormalities in both pre- and post-meiotic stages. In pre-meiotic stages cells either degenerated or became hypertorophied, while in post-meiotic stages the hypertrophied tapetal cells crushed the pollen grains. It is concluded on the basis of these findings that on account of starvation caused by poor vascular differentiation, the tapetal cells become haustorial in nature in search of nutrition. This fact is further supported by present histochemical and biochemical observations indicating deficiency of total carbohydrates of insoluble polysaccharides, DNA, histones, total proteins, enzyme acid phosphatase and free proline in the anthers of complete male-sterile plants. However, the anthers of such plants contained higher amounts of alanine and glycine as compared to their fertile counter parts.

Natural History and Adaptive Significance of Sex Switching in Gurania and Psiguria

-or-

Why do Females Have to be Big to Hang Loose?

M. Condon
Parque Nacional Guatopo
Altagracia de Orituco
Guarico, Venezuela

Part 1: Natural History and Related Problems

A long term field study of *Gurania* and *Psiguria* populations in Parque Nacional Guatopo is in progress. I report observations on morphology, sex patterns, and plant-animal interactions, drawn from three and a half continuous years' daily data.

Gurania and *Psiguria* are monoecious, not dioecious as once thought, and show strong sexual dimorphism. Male fertile branches climb. Females hang. Sexes are separate in space and time. Sex and stem diameter are related. Only plants above a critical size produce female flowers. Sexes are rarely active simultaneously. Populations have seasonal flowering peaks, but individuals with flowers of either sex are found at any time of year. "Apparent sex ratio" is seasonally variable. Within a season some individuals produce both male and female flowers and are usually protrandrous. Plants are self-compatible.

Hummingbirds and *Heliconius* butterflies visit male and female flowers. Both are pollinators and effect fertilization. Hummingbird visits far outnumber *Heliconius* visits to most plants observed during peak nectar production times in Guatopo, Trinidad, Tobago, and Ecuador.

Major florivores are the common pickle worm, *Diaphania nitidalis* (Stoll) and an unindentified tephritid fruit fly, *Blepharoneura sp.* (flower). This fly attacks only one of two sympatric *Gurania* species in Guatopo. Other florivores include a coreid bug, *Phthia lunata* (Fabr.) and chrysomelid beetles (including *Acalymma bibittulum* Kirsch or near). Major herbivores include the florivorous tephritid and chrysomelids, *Diaphania hyalinata* (L.), and microlepidopterans. Other herbivores are a pentatomid bug *Piezosternum subulatum* (Thunberg), a membracid *Hyphinoe asphaltina* (Fairmaire), and a cerambycid beetle.

Fruits are dispersed by bats. Bats are the only animals which take fruit from plants and are not known to actively damage seeds. Work with radio- and light-tagged florivorous bats is in progress with J. Bradbury. Squirrels and at least two species of arboreal mice eat embryos of seeds of ripe and immature fruit, usually in the immediate vicinity of the fruiting branch. Saltators eat mature and immature fruit. I have never seen evidence of a bird actively removing a fruit from a branch. Thus, bats are probably the most effective dispersal agents.

Three insects regularly cause high predispersal seed mortality: *Phthia lunata*; *Diaphania nitidalis*; and another unidentified tephritid, *Blepharoneura sp.* (fruit). This fly attacks both *Gurania* species in Guatopo.

I made these observations with W. S. Perkins in order to better understand the adaptive significance of sex switching and the factors which could exert strong selective pressure affecting the evolution of floral, fruit, and branch morphology. Hypotheses and methods are described in Part 2.

These observations can be useful in the development of research on cucurbit taxonomy, chemistry, morphology, physiology, and sex expression. Our life history data on *Gurania* and *Psiguria* pests and their parasites may bear upon biological control programs which seek to control populations of the same insects in agricultural situations. Dr. Gilbert, who has many similar data from greenhouses, Costa Rica, and Mexico, uses our data to see patterns in community structure and organization. Many of his insights are important for the development of intelligent conservation programs in the tropics.

Part 2: Adaptive Significance of Size Related Sex Expression: Hypotheses, Methods, and General Questions

Gurania and *Psiguria* switch sex, change from male to female sexual reproduction (and vice versa?), on two time scales: intraseasonal and interseasonal. Intraseasonal switching involves protandrous branch patterns characteristic of many cucurbits. Interseasonal switching involves change in plants' capacity to produce female flowers, which is related to stem diameter. Sex expression refers to the kind of gamete a gonad produces: males produce numerous "mobile" gametes (pollen or sperm) and females produce fewer "sessile" gametes (ovules or eggs.). What is the adaptive significance of size related sex expression in *Gurania* and *Psiguria*?. I generate hypotheses. Quantitative and qualitative data and the comparative method will be used to evaluate hypotheses.

Natural selection can affect the evolution of adaptive characters. Selection favors characters which maximize individual fitness. Fitness has two components: fecundity and survivorship. I work to determine what, if any, relationship exists between vine size, sex, and fitness. I describe methods used to measure size and fitness, and discuss problems of measuring male fecundity.

Measures of fitness alone do not reveal the adaptive significance of evolved traits. Thus, available mathematical models are of limited use to understanding the evolution of some adaptive characters.

I generate two hypotheses (which are not mutually exclusive) concerning the adaptive significance of size related sex expression in *Gurania* and *Psiguria*.

Hypothesis 1: Relationship between size and sex results from differential metabolic costs involved in production of male vs. female reproductive structures. If size reflects quantity of stored reserves, and if fruit and seed production requires use of more of those reserves than male inflorescence production requires, then selection for delayed femaleness may be due to higher mortality or reduced fecundity of plants which exhaust their stored reserves in fruit, and relatively higher fitness of plants which do not produce female flowers until a critical size is attained.

Hypothesis 2: Sexually dimorphic branch morphology may be a preadaptation for the evolution of size related sex expression. Males climb. Females hang. If the adaptive significance of climbing lies in the ability of a plant to position itself in a favorable light climate, and if the relative value of light as a resource increases with height in the forest, and if stem diameter and height are related, then selection may strongly favor climbing ability of small (diameter) vines, but not of big (diameter) vines. Thus, selection may favor vines with branches that hang only if those vines have attained a critical height in the canoopy. Critical height may be that at which a vine, on the average, experiences a light climate which allows maximum photosynthesis. Switch size may be the average diameter associated with initial attainment of critical height.

I discuss methods used to evaluate these hypotheses. Detailed data are not included because they are not yet adequately analyzed. Since limited measurements may not accurately reflect conditions in nature, I emphasize the importance of a comparative approach. Comparison of the relative sizes of sexes of different *Gurania* and *Psiguria* which occur in different forest types and/or exhibit differences in habit may be very revealing.

Not only intra-tribal, interspecific comparisons are important for understanding the evolution of adaptive characters. Knowledge of the presence or absence of similar phenomena in less closely related organisms is also critically important. Few reliable data are available on most other cucurbits. Most information on the taxonomic distribution of cucurbit sex patterns comes from herbarium or short term field studies which cannot detect many spatial and temporal phenomena. Thus, understanding of evolution of sex patterns in *Gurania* and *Psiguria* is seriously hindered by lack of long term field data on other wild cucurbit populations. I ask questions about cucurbits in general. Finally, my work raises questions of more general importance, such as: Why, given the incredible sexual flexibility allowed by flowers, which are multiple disposable gonads, has dioecy ever evolved?

Amino Acids as Chemotaxonomic Indices

Leslie Fowden
Rothamstal Experimental Station, India

All plants produce the 20 amino acid constituents of protein and certain other amino acids involved as intermediates in these biosyntheses. These primary products are not of great significance in chemotaxonomy because their concentrations mostly vary within only narrow ranges between species. Along with these essential amino acids, a second group of 'non-protein' amino acids are found as constituents of plants: individual compounds in this latter group are not universally distributed throughout the plant kingdom, and are therefore not essential metabolites in all species; they then fall into the category of secondary plant products. A number of these non-protein amino acids are characteristic constituents of members of the Cucurbitaceae; for instance, the heterocyclic amino acid, β-pyrazol-l-ylalanine and its α-glutamyl peptide, are known only in certain cucurbit species and have never been found in plants assigned to other families. A group of three amide-N substituted asparagines and *m*-carboxyphenylalanine also occur in some members of the cucurbit family. The distribution and biosynthesis of these and related compounds will be discussed, and the use of such information in classification will be illustrated by selected examples.

Genetic and Physiological Regulation of Stamens and Ovary Differentiation in the Cucumber Floral Bud—An Overview

Esra Galun
Department of Plant Genetics
The Weizmann Institute of Science
Rehovot, Israel

Based on the information which accumulated in numerous studies, as well as on our own investigations, it is attempted to construct a comprehensive view on the involvement of genetic, environmental, and chemical factors in the control of stamens and ovary differentiation in the cucumber floral bud.

The genetics of sex regulation in cucumber can be explained on the basis of three to four major genes and several modifying genes. Among the environmental factors there is undisputed proof for the roles of day-length and temperature in the sex control of this plant. Almost all major groups of growth regulators were applied on cucumber plants and many of them affect sex expression. Endogeneous levels of growth regulators, in vitro culture studies, and grafting experiments indicate that by focusing our attention on the embryonal floral bud we should gain a better understanding of the regulatory mechanisms which control stamens and ovary differentiation in the cucumber plant.

Interspecific Trisomics of Cucurbita moschata

J. D. Graham and W. P. Bemis
University of Arizona
Tucson, Arizona 85721

Phenotypic effects and transmission rates of the extra chromosome in interspecific trisomics of *Cucurbita moschata* cv. 'Butternut' ($2n$ *C. moschata* + 1 *C. palmata* chromosome) were determined and compared with those of a primary trisomic of *C. moschata*. Based on gross morphological similarities, sixteen interspecific trisomic lines were placed in six phenotypic groups, suggesting that six different *C. palmata* chromosomes were recovered. Fruit from one of the interspecific trisomics exhibited the hard rind of *C. palmata*, indicating that this dominant trait is carried on one chromosome. Some phenotypic effects of the extra chromosome were similar in both the interspecific and primary trisomics, showing a chromosomal effect due to genic imbalance. Transmission of the extra chromosome through the female ranged from l5% to 32% for the *C. palmata* chromosomes, and was 44% in the primary trisomic. None of the extra chromosomes was transmitted through the male parent.

Some Growth Regulators of the Cucurbitaceae

J. Guha and S. P. Sen
Department of Botany
Surendranath College
Calcutta, India
and
Department of Botany
University of Kalyana
Kalyani, India

The Cucurbitaceae family is fascinating for the variety of growth patterns its members exhibit. We have investigated the situation in relation to growth regulators in the fruits and seeds of l2 economically important plants belonging to this family. Gibberellins were present in all the plants investigated and the following were present in appreciable quantities: GA_1, GA_3, GA_4, GA_7, GA_9 and GA_{13}. They promoted the growth of dwarf rice and maize seedlings and cucumber hypocotyls, and induced α -amylase activity in rice endosperm halves.

In *Cucurbita moschata*, which bears very large fruits, the seeds contain more than 100 g/Kg. While purifying the gibberellins we came across a very potent growth inhibitor, a tetracyclic triterpenoid compound, cucurbitacin B, the chemical properties of which in many respects were similar to those of gibberellins. Cucurbitacin B antagonized the GA induction of α -amylase and the growth of TN-1 dwarf rice seedlings and cucumber hypocotyls. Seventeen cucurbitacins, A-Q, have been known so far. Cucurbitacins E, I, J and K possessed pronounced anti-gibberellin activity. The cucurbitacins, however, do not antagonize auxin action, but do counter the effect of cytokinins to some extent.

The product of interaction of GA_3 and cucurbitacin B has chemical properties distinct from either and possesses growth inhibitory properties. Cucurbitacin B affects membrane permeability but does nct antagonize GA_3 effects on permeability, although it reduces the GA_3 stimulation of RNA synthesis. Respiratory O_2 uptake is enhanced by both. It is suggested that the native gibberellins and the cucurbitacins, widespread in this family, regulate the growth of cucurbitaceous plants in varying degrees.

Fatty Acids of Seed Oils as a Taxonomic Character

C. Y. Hopkins
Ottawa, Canada

At least 150 different fatty acids are known to occur as components of seed oils. Some of these are typical of certain plant families, e.g. simple saturated acids in *Lauraceae*, simple unsaturated acids in *Gramineae*, and very complex unsaturated acids in *Santalaceae*.

However, there is considerable variation in types and individual acids within a family. In *Cucurbitaceae*, the species can be divided into two categories, one with simple saturated and unsaturated fatty acids, the other with highly unsaturated fatty acids with conjugated double bonds.

Genera with common edible fruits (e.g. *Cucumis* and *Cucurbita*) nave usually the ordinary unsaturated acids (oleic, linoleic) while other genera such as *Momordica* and *Trichosanthes* are noted for acids naving conjugated unsaturation (punicic, α -eleostearic).

There are exceptions, and these appear to be useful in taxonomy. The seed oils and fatty acids of many species of Cucurbitaceae are discussed in detail, along with the botanical classification.

Recent Developments in the Triterpenes and Steriods of the Cucurbitaceae

Peter J. Hylands
Department of Pharmacy
Chelsea College
University of London
Manresa Road
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Several members of the Cucurbitaceae have cathartic, anti-tumor and hypoglycaemic actions, which have been shown to be due to various tetracyclic triterpenoids and steroids. A special class of the triterpenoids—the cucurbitacins—also have insect antifeedant properties, and one compound may have potential use as a non-sugar sweetening agent. These demonstrated properties have focused interest on the triterpenoids as a group. The current state of knowledge will be reviewed.

Further, the isolation of some new pentacyclic triterpenoids may shed some light on triterpene biosynthetic processes in general. Sterol biosynthesis in the Cucurbitaceae also has some unusual aspects and some of this recent work will be discussed.

An Outline of the Cucurbitaceae

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The *Cucurbitaceae* is a moderately large family of 117 genera and 825 species, divided into two subfamilies, *Zanonioideae* (17 genera), 80 spp.) and *Cucurbitoideae* (100 genera, 745 spp.), the latter subdivided into eight tribes. The current classification is essentially syncretistic, insufficient being known about the family for the production of classification fully consonant with either phenetic or phylogenetic (cladistic) principles. While the family is well-defined morphologically, its affinities remain obscure. It is predominantly tropical, with about 90% of the species occurring in the three main areas of occurrence - Africa and Madagascar, Central and South America, South-east Asia and Malasia.

Prospect for Increasing Yield of Cucumis sativus via Cucumis hardwickii germplasm

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The increasing trend towards mechanical harvesting of pickling cucumbers has focused attention on the problem of low yield. Smith *et al.* (3) obtained variance component estimates for several traits in a simulated once-over mechanical harvest; narrow sense heritability for fruit number was .17. The reference population was derived from 18 monoecious *C. sativus* cultivars obtained from various breeding programs in the United States. The results suggested that response to selection for yield within this reference population would be slow and expensive in terms of land and labor. Smith *et al.* (3) noted that the low heritability and variance associated with fruit number in existing populations might be increased by incorporating multiple fruiting genotypes into the germplasm pool.

One possible source of multiple fruiting genotypes is *Cucumis hardwickii R.*, an annual monoecious *Cucumis* species which is thought to be either a feral or progenitor species of the cultivated cucumber, *C. sativus* L. (1). Typically, *C. hardwickii* plants are much larger than *C. sativus* cultivars, and have more and larger laterals. One of the most potentially useful characteristics of *C. hardwickii* is its ability to sequentially set large numbers of fruit. Horst and Lower (2) reported that *C. hardwickii* could average 80 fruit per plant under North Carolina conditions.

Current research in exotic populations which incorporate *C. hardwickii* germplasm is focused on the following areas:

1. Estimation of narrow sense heritability of fruit number of plant.
2. Estimation of heterotic, and gene effects.
3. Comparison of alternative breeding methods.

Literature Cited

1. Deakin, J. R., G. W. Bohn and T. W. Whitaker. 1971. J. Econ. Bot. 25:195-211.
2. Horst, E. R. and R. L. Lower. 1978. Cucurbit Genetics Co-op Rpt. #1
3. Smith, O. S., R. L. Lower, and R. H. Moll. 1978. J. Amer. Soc. Hort. Sci. 103:222-225.

Productivity and Nutritional Status of Winter Squash

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Among the Cucurbitaceae squash are considered the most efficient nutrient producers in terms of dry matter produced per acre and overall content of vitamins, minerals, proteins, and carbohydrates. In the context of the world food problem, however, squash is given little notice as a supplier of nutrients as compared to the major cereals, legumes, and vegetables. The rapid growth rate, high yield, and short growing season of some strains of squash are well documented, but seemingly overlooked is the fact that strains of *Cucurbita maxima* are efficient producers of protein. Not only are seeds high in protein (30-40%), but the flesh of the fruit of some strains contain 20% or more protein on a dry weight basis. Growing recently developed bush strains of squash under high density planting, we have obtained protein estimates for the fruit of better than 15 kg/ha/day. This places squash well above most vegetables, and on a par with the highest yielding cereals and legumes as a producer of protein. The high water content of squash is a drawback to obtaining squash protein in a concentrated form, but the protein to calorie ratio of squash is nearly as high as some of the important legumes.

The quality of squash protein in terms of amino acid balance has only been determined for a few strains, and some essential amino acids, particularly methionine, appear low. Nonetheless, because of the high yield and high protein content of strains of *Cucurbita maxima*, its wide adaptability, and its inherent genetic variability, a more thorough investigation of protein content and quality and overall nutrition seems warranted.

Phenotypic Variation of Male Fertile and Male Sterile Segregates of male sterile-1 and male sterile-2 in Muskmelon (Cucumis melo L.)

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Flowers on progenies segregating for *male sterile-1* or *male sterile-2* and on male fertile cultivars and breeding lines were scored visually and microscopically for male sterility. Flowers on segregating progenies were separated into 3 phenotypic classes: male fertile, male sterile and pseudo-male sterile (reduced, non-dehiscent anthers filled with apparently normal pollen). Three to 11 percent of the flowers on male fertile plants in progenies segregating for *male sterile-1* or *male sterile-2* were visually scored "male sterile". In contrast, only 1.2 percent of the flowers on the 5 male fertile genotypes were visually scored "male sterile". Three percent of the flowers on male sterile segregates of a sib-crossed derivative of the original *male sterile-1* progeny were pseudo-male sterile. In contrast, 36 percent of the flowers on male sterile segregates from 3 crosses of *male sterile-1* with male fertile genotypes were pseudo-male sterile. None of the male sterile segregates of a sib-crossed derivative of the original *male sterile-2* produced pseudo-male sterile flowers. Four percent of the flowers on male sterile segregates from 2 crosses of *male sterile-2* with male fertile genotypes were pseudo-male sterile.

Ethnobotany of the Old World Cucurbits

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Many members of the old world Cucurbitaceae play an important role in the social and religious life of several ethnic groups. An ethno-botanical account is presented on the use of certain species in magic rituals (*Momordica charantia*), and ceremonies (*Cucumis myriocarpus, Luffa acutangula, Momordica balsamina, M. charantia*), charms (*Lagenaria leucantha*), worship (*Trichosanthes pubera, Cucumis sativus, Cucurbita pepo, C. maxima*) etc., for the purpose of initiating and promoting further ethno-botanical studies on these and other species.

Electrophoresis of Proteins of Single Pollen Grains

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Recent studies by Puchalski and Robinson (Cucurbit Genet. Coop. Rpt. 1:28, 1978) have demonstrated that starch gel electroophoresis is a valuable addition to the methods of *Cucurbita* systematics. Another useful method, one which possesses some unique advantages, is micro-polyacrylamide gel electrophoresis. In this paper, two of these advantages, portability and sensitivity, will be demonstrated. For example, it is possible to perform this analysis in the field with no more material than a single pollen grain. Such extreme sensitivity has important applications in ecological genetics and in any other subject area in which sample materials may be too small for other types of analysis.

Resistance Breeding of the Cucumber by Interspecific Hybridization

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The working group on interspecific hybridization at the Institute for Horticultural Plant Breeding has attempted since 1977 to introduce resistance of several wild species of *Cucumis* into the cultivated cucumber, *C. sativus* L. Therefore a collection of species has been built up, at this time containing 118 identified accessions of 13 species, nearly all of African origin. In addition, many primitive forms of *C. melo*. L. and *C. sativus* were gathered.

The identification of the species proved difficult and many accessions were received under a false name. Of 76 examined in 1979, 25 accessions had to be reclassified. There seems to be a need for a revision of the genus.

Some variable resistances were found in several species. For example, *C. africanus* L.f. and *C. anguria* L. apppeared wholly resistant to cucumber green moltle mosaic (CGMV), while some of the 17 accessions of *C. metuliferus* Naud. were highly resistant to root knot nematodes (*Meloidogyne javanica* and *incognita acrita*. Many species carry resistance against powdery mildew (*Sphaerotheca fuliginea*), but none proved resistant against black root rot (Phomopsis *sclerotioides*).

The crossability of 10 African species and *C. sativus* was studied in a diallel cross on the basis of pollen tube growth in the style and fruit and seed set. Bilateral and unilateral incongruity were most common within the African group. Many crosses without prefertilization barriers yielded hybrid offspring. In some crosses post-fertilization barriers occurred like in *C. sativus* x *C. melo*. Offspring of several such crosses was secured via embryo culture. No plants were obtained from crosses between African species and *C. sativus*.

Interspecific pollinations aided by mentor pollen (irradiated maternal pollen) between *C. metuliferus*, *C. africanus* and *C sativus* regularly led to fruit set. In reciprocal crosses between the two wild species, about I/3 of the fruits obtained contained ovules with an embryo, but there were only few such ovules per fruit. The crosses with *C. sativus*, however, yielded only a few ovules with possible embryo growth.

Amino-ethoxyl-vinyl-glycine (AVG) applied at pollination time in crosses between *C. africanus* and *C. metuliferus* induced fruit formation less effectively than mentor pollen, but all fruits contained high percentages of embryos. Preliminary combined mentor pollen/AVG aided pollinations gave good fruit set, while most fruits contained ovules with embryos. AVG did, however, not yield embryos in crosses with *C. sativus*.

Extension growth of embryos of *C. africanus* x *C. metuliferus* slowed down four weeks after pollination, but continued in those of the reciprocal cross. The latter embryos when 3-4 mm long were induced to develop into normal plantlets on a medium containing 10 mg/l kinetin. The plantlets were transferred into soil and appeared to be true hybrids.

Variability in Indian Melons (Cucumis melo L.)

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Eighteen cultivated and wild melons of India along with an improved muskmelon cultivar 'Annamalai' were evaluated for fifteen horticultural traits. Significant differences existed among the melon forms for all the characters studied. Out of fifteen characters studied, thirteen characters showed high heritability coupled with high genetic advance. Earliness and number of primary branches showed poor genetic advance. The Indian melons offer good scope in muskmelon breeding.

Electrophoretic Profile of Water-soluble Proteins (albumins) Isolated From Seeds of Various Species of the Cucurbitaceae Family

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IEF-electrophoretic patterns of seed albumins were determined for *Cucurbita pepo*, *C. moschata*, *Luffa cylindrica*, *Lagenaria vulgaris*, and *Momordica charantia*. The albumins of each species were resolved into various protein components differing in their isoelectric points. Most of them were identified as acidic components. The total number of major and minor components of albumins varied from 8 to 17. The densito-metric scans showed the albumin components with isoelectric points identified in the range of 5.05—5.70 pH to be present in considerably high quantity. It seems to be probable that these "low pH" protein components, at least in this case, constitute a substantial part of total seed albumin fraction. From the results obtained here, it is evident that the seed albumin profiles appear to be a species specific trait.

Viral Diseases and Genetic Sources of Resistance in Cucurbita

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Viral diseases are of frequent occurrence in Cucurbitaceae grown in the Northeast United States, and in New York State in particular. Cucumber mosaic virus (CMV), the severe strain of bean yellow mosaic virus (BYMV-S), watermelon mosaic virus 1 (WMV-1), and watermelon mosaic virus 2 (WMV-2) are aphid transmitted. Tobacco ringspot virus (TRSV) and tomato ringspot virus (TmRSV) are spread by nematodes. Squash mosaic virus (SqMV) is transmitted by seed and beetles. Aster yellows, which is caused by a mycoplasma, is of rare ocurrence in squash.

In the genus *Cucurbita*, sources of immunity, resistance or tolerance have been found in species indigenous to the southern USA, Central and South America. Of 15 feral species, separately inoculated with the seven viruses, 12 species were resistant to CMV or to TRSV. Seven species were immune to both WMV-1 and WMV-2, and two species were tolerant to WMV-2. Seven species were resistant to TmRSV, whereas only three were tolerant to SqMV. Immunity to BYMV-S and resistance to TmRSV were also found among cultivated species.

Cucurbita ecuadorensis, *C. foetidissima*, and *C. ficifolia* are the best sources of multi-resistance since they are immune to WMV-1 and WMV-2, and resistant to CMV and TRSV. In addition, *C. ecuadorensis* is tolerant to SqMV, *C. ficifolia* is immune to BYMV-S and resistant to TmRSV, and *C. foetidissima* is immune to BYMV-S.

Because of their compatibility with one or more cultivated species, *C. ecuadorensis* and others, such as *C. martinezii*, are valuable germplasm material for interspecific gene transfer.

Cucurbita foetidissima and *C. ficifolia* are also of great potential value provided that their incompatibility with the cultivated species can be overcome.

Electropohoretic Analysis of Isozymes in Cucurbitaceae and its Application for Phylogenetic Studies

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Studies were carried out on the cucurbit collection of the New York State Agricultural Experiment Station, with 398 taxons representing 27 genera and 94 species, including 19 species of *Cucurbita* and 28 species of *Cucumis*. The youngest leaves of field-grown plants were used for isozyme analysis, using starch gel slab electroophoresis. Multiple forms of esterase, peroxidase, and leucine aminopeptidase were detected.

It was found that all species possess their own specific patterns of isozymes, especially esterase, and isozymes were shown to be very sensitive markers for distinguishing and identifying all analyzed species and genera. This technique was also helpful for determining the genetic relationship between several species and predicting their crossing relationships. Isozymic markers were applied also for identification and classification of cultivars of *Cucurbita pepo*, *C. moschata* and *C. mixta*.

On the basis of electrophoretic enzymes patterns, taxonomic classifications of all analyzed species in the genera *Cucurbita* and *Cucumis* were prepared. The genus *Cucurbita* was divided into five species groups, and the *Cucumis* species were separated into four species groups, according to their reciprocal similarity. Generally the obtained results were similar to other classifications based on other taxonomic traits, especially morphological, but the isozymes techniques seems to be more valuable for phylogenetic studies in Cucurbitaceae. The main advantages are: better sensitivity and easier detection of interspecific differences including those in young seedlings; repetitive and exact results; and possibility of application for mass screening.

Cucurbita Species Hybrids as a Source of Cucurbitacins

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We have been experimenting with cucurbitacins as a tool for monitoring the Diabroticite beetle population in cucurbit plantings and in corn fields. Our initial source of cucurbitacins was obtained from fresh fruit-pulp of wild spp. of *Cucurbita*. The beetles are voracious feeders on the bitter pulp and they will eat until the pulp is entirely consumed. When an insecticide is added to the pulp, the beetles are readily killed for a period of up to at least 7 days. Because we wished to enlarge the scope of these studies, we began looking for a more economical means of producing cucurbitacins than via the wild spp. Hybrids among wild spp. did not solve the problem, but some hybrids of wild domesticated spp. produced abundant fruits with relatively high concentrations of cucurbitacins. The best early source was obtained from a cross of *C. texana* x *C. pepo*, and the best main season source was *C. andreana* x *C. maxima*. Wild spp. *C. lundelliana* and *C. palmeri* crossed with *C. moschata* did not produce as high a concentration of cucurbitacins as the first 2 crosses. This past year (1979), we dried about a ton of fresh fruit from the *C. andreana* x *C. maxima* hybrid. A most disagreeable task was the milling of the bitter dried fruits in preparation of cucurbitacin extraction. Even after several months storage, the ground product is still an irritant to the nose. We are now selecting in segregating populations of several wild x domesticated spp. crosses for the "ideal" gourd—high yield of cucurbitacins per unit of land. As a precaution, we are selecting towards unattractive fruit colors and shapes to discourage pilferage and in turn lessen the chances of adverse after-effects on those who might wish to sample the fruit.

Genetics and Breeding of Cucurbita and Cucumis

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Cucumis is the best genetically known genus of the Cucurbitaceae, with at least 127 known genes, including 78 for *sativus*, 48 for *melo*, and 1 for *metuliferus*. The genus with the next largest number of reported genes is *Cucurbita*, most of them (26) for *C. pepo*, 7 for *maxima*, 2 for *okeechobeensis*, and one each for *foetidissima* and *lundelliana*. Known genes of importance for cucurbit breeding will be discussed.

Very little is yet known about gene linkage relationships in the Cucurbitaceae. The cucumber, with fewer chromosomes than any other cultivated cucurbit and with apparently nonrandom distribution of genes on its chromosomes, is subject to considerable gene linkage. Among the cases of linkage or pleiotropy of genes of economic importance encountered by cucumber breeders are for those governing fruit shape and color, parthenocarpy, sex expression, earliness, skin toughness, carpel number, bitterness, and resistance to insects, *Erwinea tracheiphila*, *Sphaerotheca fuliginea*, *Pseudoperonospora cubensis*, and *Cladosporium cucumerinum*.

Interspecific transfer of genes is expected to play an increasingly important role in the breeding of *Cucumis* and *Cucurbita* in the future. The potential of using wild species in breeding *Cucumis* and *Cucurbita* will be discussed.

Evolution in the Genus Luffa

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The taxonomic status of different species of *Luffa* is far from clear. Four of its species, namely, *L. graveolens*, *L. echinata*, *L. cylindrica* and *L. acutangula*, of which the two former are wild and the latter cultivated, are well established. Other described species of *Luffa* are synonyms of either the cultivated species *L. cylindrica* or that of the wild *L. echinata*. Detailed cytogenetic investigations were carried out involving all four species of *Luffa*. They possessed a somatic chromosome number of 26 with close karyotypic similarities. Hybridizations in all possible combinations, both direct and reciprocal, revealed a number of interesting features. The two cultivated species were genetically close, so much so that *L. cylindrica* x *L. acutangula* hybrids were fertile with nearly normal meiosis during microsporogenesis. The wild species *L. graveolens* showed the greatest hiatus from other species. The dioecious species *L. echinata* represented another line of evolution. The present study, which included detailed cytological study of the parents and their hybrids, has attempted to place the taxonomy of *Luffa* on a cytogenetic footing with an additional advantage that the known interrelationships of different species could be utilized in the improvement of the cultivated species through selected breeding.

Dioecism in Cucurbitaceae

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The cucurbits display diverse sex forms, and several of its dioecious taxa provide an excellent material for the study of evolution of dioecy in this family. From an investigation of five dioecious species belonging to as many genera, a definite line of evolution emerges out. Three dioecious species, viz., *Luffa echinata*, *Melothria heterophylla* and *Momordica dioica*, represent the first category in which the differentiation of sex is entirely genic without any cytological evidence of heterogamety. The dioecious species *Trichosanthes dioica* falls in the second group where, although there is no heteromorphy in the male and female chromosomal complements, the microsporogenesis displays in regard to a pair of chromosomes distinct patterns of abnormality which could be correlated with dioecy. In the last category belongs *Coccinia indica* with a distinct X/Y mechanism of sex differentiation and male heteromorphy. Using detailed cytological investigation as the basis for the present study, the evolutionary trend in regard to dioecy will be discussed.

Nitrogen Nutrition of Cucurbits

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The nitrogen content of many cucurbits is quite often much higher than the soils, on which they grow, can provide; this is particularly true for cucurbits which grow luxuriantly on sandy soils. Investigations carried out by us during the last five years have revealed the presence of active N_2-fixing bacteria in the phyllosphere of most of the cucurbits examined. In morphological and biochemical characteristics, including the GC content of DNA, the bacteria seem to belong to certain biotypes of *Klebsiella pneumoniae*. Some of these isolates when sprayed on rice and wheat plants in N-less sand culture meet the nitrogen needs of such plants almost entirely. Similar results were also obtained under field conditions. Treatment of the microorganisms with such plasmid-curing agents as acridine orange and ethidium bromide eliminated their N_2-fixing capacity, suggesting that the *nif* gene in these microorganisms may be plasmid-carried. Subsequent experiments have revealed that callus tissues obtained from leaf cells of various cucurbits obtained from different parts of the world grow in N-less Murashige and Skoog's medium; such cultures have been maintained for more than a year now. The callus tissue reduces acetylene to ethylene and their nitrogen content increases with time. However, the fixation rate is lower than in the case of root nodules.

It appears that during the long period of association of N_2-fixing microorganisms with the foliage of cucurbits, the *nif* gene of such microorganisms has been incorporated in the leaf cells of cucurbits. Nitrogen requirement of cucurbits is met partly by N_2 fixation through the activity of the *nif* gene and largely by the N_2-fixing microorganisms which inhabit their leaf surfaces.

The Concept of Timer-genes in Relation to Fruit Pigmentation and Quality in Cucurbita

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The races of *C. pepo* and *C. maxima* can be grouped under two genetic systems of fruit pigmentation, the standard *b*-system and the precocious *B*-system, *B* being a mutant. In the *b*-system, fruits of different cultivars either remain green throughout their development or turn to other colors (orange, yellow, cream, or white) at different times, from 48 hours before anthesis to over 20 days after anthesis. In the *B*-system, color differentiation is initiated in the "bud phase" and fruits of different lines are either completely pigmented (orange, yellow, cream, or pink) or bicolor depending on whether the onset of differentiation occurs early or late during the bud phase. Gene *B* and its precocious alleles can exhibit many "secondary" effects on plant growth, sexuality, and fruit quality. Most secondary effects are detrimental but some are beneficial. Potentially, a secondary effect can be expressed or suppressed depending on the constellation of genes with which *B* interacts in a given background. These and other observations have led to the hypothesis that the two systems carry genes which control the time at which chlorophyll synthesis is blocked during fruit development; that *B* is a precocious timer of regulatory functions; that *B* is associated with a diffusible substance which inhibits the activities of some genes and promotes the activities of others; and that the affected genes include genes for synthesis of chlorophylls, carotenoids, and various constituents of fruit quality. It should be possible to develop well-adapted *B*-cultivars of superior fruit quality through gene recombination.

F_1 Hybrid Cucurbit Seed Production

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In summer squash (*Cucurbita pepo*) inbred development a careful inbreeding program is followed, selecting for blossom placement and for timing relations of pistillate and staminate flowers. If an inbred is to be used as seed parent of a hybrid, it must yield and germinate well.

Planting ratio for hybrid seed production is two seed parent rows to one pollen parent row. Honey bees are used as pollinators. Ethephon is used to depress staminate flowering. Pollen rows are removed upon completion of the pollination period.

Isolation is one of the most important problems. Sources of contamination can be from our own production or family gardens.

Seed harvest uses a home-made seeder. Seeds are washed to remove pulp, then dried at 100 to 105 F and processed to remove light seed and inert material.

For Cucurbitaceae Conference
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COEVOLUTION OF CUCURBITA AND DIABROTICITES

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ABSTRACT

The coevolutionary association between the Cucurbitaceae and the Beetles of the tribe Luperini, family Chrysomelidae, provides a classic example of the role of secondary plant substances, as Kairomones promoting host selection and feeding by phytophagous insects. The Cucurbitaceae contain some 900 species in about 100 genera and there are about 1500 species of Luperini including the dominant New World Diabroticites and the Old World Aulacophorini. Current thinking holds that the oxygenated tetracyclic triterpenes, the cucurbitacins that are responsible for the characteristic bitter taste of the wild Cucurbitaceae, were selected by evolutionary processes to protect these plants against attack by herbivores both vertebrate and invertebrate. The cucurbitacins are the most intensely bitter substances yet identified and can be detected at ppb levels. Somewhere in the evolutionary process, following the Cenozoic Era, the Luperini beetles began to use the cucurbitacins as arrestants and feeding stimulants and thus began to diversify as the major herbivores attacking Cucurbitaceae. Although host records are meagre, we have identified 50 species of Luperini as feeding on Cucurbitaceae. This list includes 25 species of New World Diabroticites.

Six species of Diabroticites have been studied in the laboratory and found to be compulsive feeders on pure chemically identified cucurbitacins B, E, D and I, and their glycosides. The limit of detection by the beetles is as low as 1 nanogram. Although many of the Luperini remain as the most important insect pests of Cucurbitaceae in both the Old and New Worlds, others particularly the notorious corn rootworms _Diabrotica longicornis_ and _D. virgifera_ have become identified as major pests of corn. Yet these corn rootworms still retain sensory organs primarily tuned to the cucurbitacins and respond to their presence by compulsive feeding.

It is tempting to suggest that the original coevolutionary association between Cucurbitaceae and Diabroticites developed in Central America or northern South America where both the genera _Cucurbita_ and _Diabrotica_ have reached maximum diversity. We are presently using isozyme and other biochemical techniques to explore the details of this evolutionary association and to establish a geological time-frame of coevolutionary diversification of both plants and insects.

Biochemical Aspects of Hormonal Regulation of Sex Expression in Cucurbits

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It was demonstrated that four groups of growth hormones are involved in sex expression in cucurbits: ethylene, gibberellins, auxins and ABA. High ethylene level is favorable to female sex expression and it is suggested that it affects the formation of the ovary in cucumber, muskmelon and squash, but is affecting male flower production in watermelon. It is proposed that auxin is affecting the early evolution of ethylene. Gibberellin plays a key role in promoting male sex expression and is antagonistic to that of ethylene and ABA. Gibberellin effect on male flower production is in a different site. The major role of ethylene in determining flower sex is supported by the interfering with ethylene biosynthesis and action. Inhibition of ethylene production by AVG, and ethylene action by $AgNO_3$ and CO_2 promote male flowers. In the general scheme for metabolism of methionine to ethylene as proposed by Adams and Yang (Proc. Natl. Acad. Sci. 76:170-174, 1979) AVG blocks the conversion of SAM to ACC and auxin induced the conversion. Silver nitrate and CO_2 may not affect directly the conversioin of methionine to C_2H_4 but may interfere with the primary action of ethylene in the tissue.

The Potential Economic Importance of the Cucurbitaceae, and the Use of Species in the Family as Experimental Material

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The potential economic importance of certain under-utilized species of the Cucurbitaceae is considered. Seven species are suggested as examples that need to be more thoroughly examined, and possibly exploited for food and drug products. They are: *Cucurbita ficifolia* Bouche; *Cyclanthera pedata* Schrad.; *Praecitrullus fistulosus* Pang.; *Cucumis anguria* L.; *Cucumeropsis mannii* Naud.; *Telfaira pedata* (Sims) Hook.; and *Hodgsonia macrocarpa* Cogn.

Some of the broad archealogical, biological and biochemical problems peculiar to the Cucurbitaceae are identified and discussed. Examples given are: (1) the need for synthesis of the available information that will yield a better understanding of the position of the Cucurbitaceae within proposed phylogenetic systems; (2) the need for extensive comparative palynological data in species within the family; (3) the need for improved recovery and identification techniques of plant materials as a means of providing accuracy and credibility to the archeological record for *Cucurbita* and *Lagenaria*; and (4) the remarkable association of insects with species of the Cucurbitaceae as exemplified by the work of Metcalf and Rhodes with the *Diabrotica* beetles should be sought in other groups. The unique role of the squash and gourd bees as pollinators of *Cucurbita* as deciphered by Hurd and Lindsley might hold true for pollinators in other groups.

<u>Morphological, Ethnobotanical, and Archaelogical Research with Acanthosicyos horrida</u>

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The first section describes the morphology and habits of this species which is endemic to the Namib Desert of Africa. The second section deals with ethnobotanical aspects of the behavior of Toopnaar Hottentoots in the marketing of nara kernels. The third part of the paper describes archaeological work in the Namib Desert where nara seed coats were found among other plant remains in a layered deposit dating back over 8,000 years.

Sur quelques structures épidermiques et anatomiques chez les Cucurbitacées xérophiles crassulescentes de Madagascar: aspects adaptatifs et phylogéniques

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Résumé: l'originalité des Cucurbitacees de Madagascar est mise en évidence par la présence de deux genres endémiques chez lesquels la crassulescence se manifeste soit dans les feuilles (Xerosicyos), soit dans les tiges (Seyrigia).

Une étude anatomique des feuilles et des tiges a été realisée avec examen des surfaces épidermiques au microscope électronique à balayage et au moyen de répliques à l'acétate de cellulose.

Une discussion comparative fait suite en mettant l(accent d'une part sur la densité des stomatique des plantes vivants comme les représentants de ces deux genres malgaches, dans des conditions de sècheresse, d'autre part sur la forme des stomates et leur place dans l'épiderme. Quelques considerations sur les aspects phylogeniques du probleme sont évopueses.

Adaptative and Phylogenetic Aspects of Some Epidermal and Antomical Structures in Succulent Xerophilous Cucurbitaceae of Madagascar

Summary: The originality of the Cucurbitaceae of Madagascar is revealed by two endemic genera with succulent leaves (Xerosicyos) or stems (Seyrigia). Anatomical studies of leaves and stems with close examination of epidermal structures have been carried out with modern techniques (scanning microscope, acetyl-cellulose reverse film (imprints).

The ensuing comparative discussion emphasizes the density of stomata in plants living in dry conditions or like the representatives of the two above mentioned genera as well as the form and position of the stomata within the epidermis.

The phylogenetic aspects of the problem are briefly discussed.

<u>Palynology of Indian Cucurbitaceae</u>

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One hundred eight species belonging to 34 genera of Cucurbitaceae occur in India, 69 species of 34 genera have been studied. Palynologically the subfamily Zanonioideae is remarkably homogeneous. Pollen grains are small, 3-zonocolporate, prolate to subprolate with striate exine in <u>Actinostemma</u>, <u>Gomphogyne</u>, <u>Gymnostemma</u>, <u>Hemsleya</u>, <u>Neoalsomitra</u> and <u>Zanonia</u>. The Cucurbitoideae is eurypalynous. Pollen grains are 3-zonocolporate, non-operculate and non-spiny in Thladianthiinae of Joliffieae and Benincasineae of Cucurbitaceae. But in <u>Thladiantha calcarata</u> and <u>Diplocyclos palmatus</u>, they are 3-zonoporate and operculated in the latter. The exine is finely faveolate in <u>Lagenaria</u> and spiny in <u>Diplocyclos</u> and <u>Praecitrullus</u>.

In <u>Cucurbita</u> (Cucurbitinae) the pollen grains are spherical, pantoporate, operculate and spiny. They are 3-zonocolporate and reticulate in <u>Luffa</u> (Luffineae) and <u>Schizopepon</u> (Sicyoeae), 5(-7)-zonocolporate, pentangulate and punctate in <u>Cyclanthera</u> (Cyclanthereae) and 10-zonocolpate and spinate in <u>Sechium (Sicyoeae)</u> <u>Trichosanthes</u> and <u>Gymnopetalum wightii</u> (Trichosanthinae) have 3(-4)-zonoporate grains which are 3-zonocolporate in <u>Gymnopetalum cochinchinense</u> and <u>Hodgsonia</u> (Hodgsoninae). Pollen grains are 3-zonoporate and operculate in Herpetosperminae but are 3-zonocolporate in Trichomeriinee. In Melothriinae the pollen grains are 3-zonocolporate but 3-zonoporate in <u>Cucumis</u> and <u>Mukia</u>. <u>Dicoelospermum</u> also have 3-zonoporate grains.

The NPC - analysis of the investigated members has enabled the recognition of 9 morphoforms in the family.

Seed-Coat Anatomy of the Cucurbitaceae

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Cucurbitaceae is a large family with two sub-families, Cucurbitoideae and Zanonioideae. Broadly, the Cucurbitaceae follow a common pattern of seed coat development and the mature structure is elaborate and largely derived from the outer epidermis of the outer integument. The inner integument is non-plicate and degenerates in fertilized ovules. The outer epidermis undergoes two periclinal divisions forming three layers e, e" and e' in succession. The layer e' usually divides only anticlinally in Cucurbitoideae but undergoes anticlinal as well as periclinal divisions in Zanonioideae. For the latter, the development of seed coat has been studied in *Actinostemma tenerum* only and the structure of mature seed in *Fevillea peruvianum*, *Gerrardanthus grandiflorus*, *Zanonia indica* and *Sicydium tamnifolium*. The mature seed coat in Cucurbitoideae usually consists of 5 zones, viz., (a) seed epidermis, (b) seed hypodermis, (c) main sclerenchymatous layer, d) aerenchyma and (e) inner zone of chlorenchyma and parenchyma. In Zanonioideae the main sclerenchymatous layer is poorly or not at all demarcated from the remaining sclerenchymatous layers of the seed hypodermis but the aerenchyma is well developed and the cells are with characteristic fibrous lignified thickenings. The shape, size and thickness of cells and the number of layers forming seed hypodermis provide useful criteria for seed identification.

The data on seed anatomy are also useful in taxonomy. The plicate nature of e' in members of Zanonioideae is undoubtedly a variation of greater magnitude than recorded among the members of the tribes of Cucurbitoideae. However, the similarities in the development and structure of seed coat in Cucurbitoideae and Zanonioideae are indicative of close affinity among them and supports the view that Zanonioideae belongs to the family Cucurbitaceae.

The relationships of Cucurbitaceae are much disputed. It has been included in Apetalae, Polypetalae and Sympetalae. A comparison of seed coat structure of Cucurbitaceae with that of the family usually considered related to it, clearly shows that the development and structure of seed coat in Cucurbitaceae are unique. The family is sufficiently isolated and deserves an ordinal status with an advanced and terminal position in Polypetalae.

Embryology of the Cucurbitaceae

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The development of anther wall is "Dicotyledonus type". Anther wall consists of epidermis, fibrous endothecium, 1-3 ephemeral middle layers and glandular tapetum. In *Luffa cylindrica* the tapetum forms a periplasmodium which is absorbed *in situ*. The tapetal cells become 2-nucleate, rarely polynucleate but Turala (1958, 1961) who has reported uninucleate condition in *Cucurbita pepo*, *Cucumis sativus*, *Cyclanthera pedata*, *Echinocystis lobata*, *Momordica charantia* and *Sicyos angulatus* considers that further differentiation in the tapetum is through endomitosis. Microsporogenesis is normal and cytokinesis results in the formation of tetrahedral, isobilateral and decussate tetrads of microspores. Enucleate cytoplasmic nodules are observed in the developing male gametophyte of *Cucurbita pepo*, *Trichosanthes bracteate* and *T. dioica*. The vegetative nucleus is usually uninucleolate but rarely becomes multinucleotate in *Mukia scabrella*, *Edgaria darjeelingensis*, *Luffa cylindrica*, *Trichosanthes dioica* and *T. lobata*. The pollen grains are shed at 2-celled stage. They are usually monosiphonic, rarely polysiphonic in germination. Abnormalities in the development of male gametophyte are reported in artificially produced triphoid watermelon and tetraploid melon.

The ovules are anatropous, bitegmic and crassinucllate. The nucellus is flask-shaped and its beak is narrow and reached to various levels in the micropylar canal which is formed by the inner integument. The female archesporium is uni- or multicellular but usually one megaspore mother cell differentiates. Meiosis is normal and results in the formation of a monosporic Polygonum type of embryo sac. Bicporic Allium type of embryo sac development is observed in *Benincasa cerifera*. In *Momordica charantia* in some of the ovules development of embryo sac directly from the archesporial cells is reported. Twin megaspore mother cells and embryo sacs have also been frequently described. In triploid watermelon and tetraploid melon meiotic irregularities forming tetrads and triads of megaspores containing besides normal nuclei, many micronuclei are observed. Embryo sacs developing from such megaspores usually abort. Somatic apospory is recorded in *Cucumis metuliferus*.

The pollen tube is persistent and porogamous. It dilates on entering the nucellus and is rarely branched. The endosperm development is nuclear and the wall formation is centripetal. The endosperm carries a chalazal coenocytic or partly or completely cellular haustorium. Rarely the haustorium is absent as in *Ctenolepis garcinii*, *Corallocarpus conocarpus*, *Melothria leucocarpa* and *Solena heterophylla*. The formation of enucleate cytoplasmic nodules in endosperm is observed in many cucurbits.

The embryogeny in Cucurbitoideae shows Nicotiana variation, Solanad type or Myosurus variation, Asterad type. It has not been sufficiently studied in Zanonioideae but early cleavages in zygote are transverse forming a filamentous pro-embryo in *Fevillea cordifolia* and *Actinostemma tenerum*. Adventive embryony is recorded in *Cucumis melo* var. *pubescens*, *Momordica charantia* and *Sicyos angulatus*. The mature embryo is straight, spatulate and dicotyledonous, rarely hemitri- and hemitetracotyledonous in *Marah macrocarpa*.

Cucurbitaceae have several distinctive embryological features.

Known Genes of the Cucurbitaceae

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Species	Preferred gene symbol	Synonym	Name	Reference
Bryonia dioica	f		few vascular bundles	8
"	s		shiny (waxless) fruit	8
Citrullus lanatus	a		andromonoecious	8
"	Af		Aulacophora foveicollis resistance	9
"	Ar	(B, Gc)	Anthracnose resistance	8
"	C		Canary yellow flesh	8
"	d		dotted seed	8
"	db		Didymella bryoniae resistance	9
"	dw-1		dwarf-1	8
"	dw-2		dwarf-2	8
"	e	(t)	explosive rind	8
"	f		furrowed fruit	8
"	Fwr		Fruit fly resistance for watermelon	9
"	g	(D)	light green skin	8
"	g^s	(d^s)	striped green skin	8
"	go	(c)	golden	8
"	gms	(ms_g)	glabrous male sterile	8
"	l		long seed	8
"	m		mottled skin	8
"	nl		nonlobed	8
"	O		Oval fruit	8
"	p		pencilled skin	8
"	pm		powdery mildew susceptibility	8
"	r		red seed	8
"	s		short seed	8
"	su	(su^{Bi})	suppressor of bitterness	8
"	t	(b^t)	tan seed	8
"	w		white seed	8
"	Wf	(W)	White flesh	8
"	y		yellow flesh	8

Cucumis melo	a	(M)	andromonoecious	8
"	ab		abrachiate	8
"	Af		Aulacophora foveicollis resistance	8
"	Ag		Aphis gossypii tolerance	8
"	Al-1		Abscission layer-1	9
"	Al-2		" " -2	9
"	b		bush	8
"	Bi		Bitter	9
"	dc-1		Dacus cucurbitae resistance-1	9
"	dc-2		" " " -2	9
"	Fom-1	(Fom_1)	Fusarium oxysporum melonis resistance-1	8
"	Fom-2	(Fom_2)	" " " " -2	8
"	g		gynomonoecious	8
"	gf		green flesh	8
"	gl		glabrous	8
"	gp		green petals	8
"	h		halo	8
"	jf		juicy flesh	9
"	l		lobed	8
"	Mc		Mycospaerella citrullina resistance	8
"	Mc-2	(Mc^i)	" " "	8
"	ms-1	(ms^1)	male sterile-1	8
"	ms-2	(ms^2)	" " -2	8
"	n		nectarless	8
"	O		Oval fruit	8
"	p		pentamerous	8
"	Pa		Pale green foliage	4
"	Pm-1	(Pm^1)	Powdery mildew resistance-1	8
"	Pm-2	(Pm^2)	" " " -2	8
"	Pm-3	(Pm^3)	" " " -3	8
"	Pm-4	(Pm^4)	" " " -4	8
"	Pm-5	(Pm^5)	" " " -5	8
"	r		red stem	8
"	ri		ridged fruit	9
"	s		sutures	8
"	So		Sour	8
"	sp		spherical fruit	8

Cucumis melo	st		striped eipcarp	8
"	v		virescent	8
"	w		white fruit	8
"	wf		white flesh	
"	Wi		White immature fruit	8
"	Wmv		Watermelon mosaic virus-1 resistance	12
"	Wt		White testa	8
"	Y		Yellow epicarp	8
"	yg		yellow green leaves	8
"	yv		yellow virescence	
"	*		nonpreference resistance to Aphis gossypii	3
Cucumis metuliferus	Wmv		Watermelon mosaic virus 1 resistance	9
Cucumis sativus	a		androecious	8
"	ap		apetalous	2
"	Ar		Anthracnose resistance	8
"	B		Black spines	8
"	B-2	(C)	Black spines-2	8
"	bi		bitterfree	8
"	bl	(t)	blind	8
"	Bt		Bitter	8
"	Bw		Bacterial wilt resistance	8
"	c		cream fruit	8
"	Cca		Corynespora cassicola resistance	9
"	Ccu		Cladosporium cucumerinum resistance	8
"	cd		chlorophyll deficient	8
"	cl		closed flower	8
"	cla		Colletotrichum lagenarium resistance	9
"	Cm		Corynespora melonis resistance	9
"	Cmv		Cucumber mosaic virus resistance	8
"	co		green corolla	8
"	cp		compact	8
"	cr		crinkled leaf	8
"	D	(g)	Dull skin	8
"	de	(I)	determinate habit	8
"	df		delayed flowering	8
"	dl		delayed growth	2

	Cucumis sativus	dm	(P)	downy mildew resistance	8
	"	dw		dwarf	8
	"	F	(Acr, D, st)	Female	8
	"	Fba		Flower bud abortion	9
	"	Foc		Fusarium oxysporum cucumerinum resistance	9
	"	g		golden leaves	8
	"	gb	(n)	gooseberry fruit	8
	"	gc		golden cotyledon	8
	"	gi		gingko	8
	"	gl		glabrous	8
	"	glb		glabrate	8
	"	gy	(g)	gynoecious	8
	"	H		Heavy netting	8
	"	I		Intensifier of P	8
	"	In-de	In(de)	intensifier of de	8
	"	In-F	(F)	intensifier of F	8
	"	l		locule number	8
	"	ls		light sensitive	8
	"	m	(a, g)	andromonoecious	8
	"	m-2	(h)	andromonoecious-2	8
	"	ms-1		male sterile-1	8
	"	ms-2		" " -2	8
	"	n		negative geotropism	8
	"	O	(y)	Orange-yellow corolla	8
P	"	P		Prominent tubercles	8
	"	Pc	(P)	Parthenocarpy	8
	"	pl		pale lethal	8
	"	pm-1		powdery mildew resistance-1	8
	"	pm-2		" " " -2	8
	"	pm-3		" " " -3	8
	"	pr		protruding ovary	8
	"	R		Red fruit	8
	"	rc		resolute cotyledon	8
	"	ro		rosette	11
	"	s	(f, a)	spine size	8
	"	sc	(cm)	stunted cotyledons	8
	"	T		Tall	8

Cucumis sativus	td		tendrilless	8
"	te		tender skin	8
"	Tr		Trimonoecious	8
"	Tu		Tuberculate fruit	8
"	u	(M)	uniform fruit color	8
"	v		virescent	8
"	vvi		variegated virescent	8
"	w		white fruit	8
"	wf	(w)	white flesh	8
"	Wmv		Watermelon mosaic virus 2 resistance	8
"	yc-1		yellow cotyledons-1	8
"	yc-2		yellow cotyledons-2	8
"	yf	(v)	yellow flesh	8
"	yg	(gr)	yellow green	8
"	yp		yellow plant	8
"	*	(dl)		7
"	*		Dominant gene for powdery mildew resistance	6
Cucurbita foetidissima	*	(a)	antherless	1
Cucurbita lundellian	Pm		Powdery mildew resistance	8
Cucurbita maxima	bl		blue fruit	8
"	Bu		Bush	8
"	Est		Esterase	8
"	Lap		Leucine aminopeptidase	8
"	M		Mottled leaves	8
"	Rd		Red fruit skin	8
"	s		sterile	8
Cucurbita okeechobeensis	cr		cream corolla	10
"	i		intensifier of cr	10
Cucurbita moschata	M		Mottled leaves	8
"	*		2 genes for pollen proteins	5
Cucurbita pepo	a		androecious	8
"	B		Bicolor fruit	8
"	Bi		Bitter	8
"	Bu		Bush	8
"	C		Colored (green) fruit	8

Cucurbita pepo	cu		cucurbitacin content	8
"	D		Dark green skin	8
"	Di		Disc fruit	8
"	Hr		Hard rind	8
"	l		light fruit color	8
"	lt		leafy tendril	8
"	ly		light yellow corolla	8
"	M		Mottled leaves	8
"	ms-1	(ms_1)	male sterile-1	8
"	ms-2	(ms_2)	" " -2	8
"	n		naked seeds	8
"	r		recessive white fruit	8
"	ro		rosette	8
"	s		sterile	8
"	St	(1^{st})	Striped fruit	8
"	W		White fruit	8
"	Wf		White flesh	8
"	Wt		Warty	8
"	Y		Yellow fruit	8
"	ys		yellow seedling	8
Lagenaria siceraria	Af		Aulacophora foveicollis resistance	9
"	b		bottle fruit shape	9
"	Bi		Bitter	9
"	db		dumbbell	9
"	G		dark Green fruit	9
"	lb		light brown seed	9
"	r		round fruit	9
Luffa acutengula	n		node color	8
"	P		Pitted seed	8
Melothria medraspatana	s		small seeds	9
"	w		white seeds	9
Momordica charantica	lbs		light brown seed	9
"	ls		large seed	9
"	w		white epicarp	9

*No gene symbol assigned yet.